NTSB Investigation Hearing
787 Li-Ion Battery
Panel 3 — Battery Design Validation

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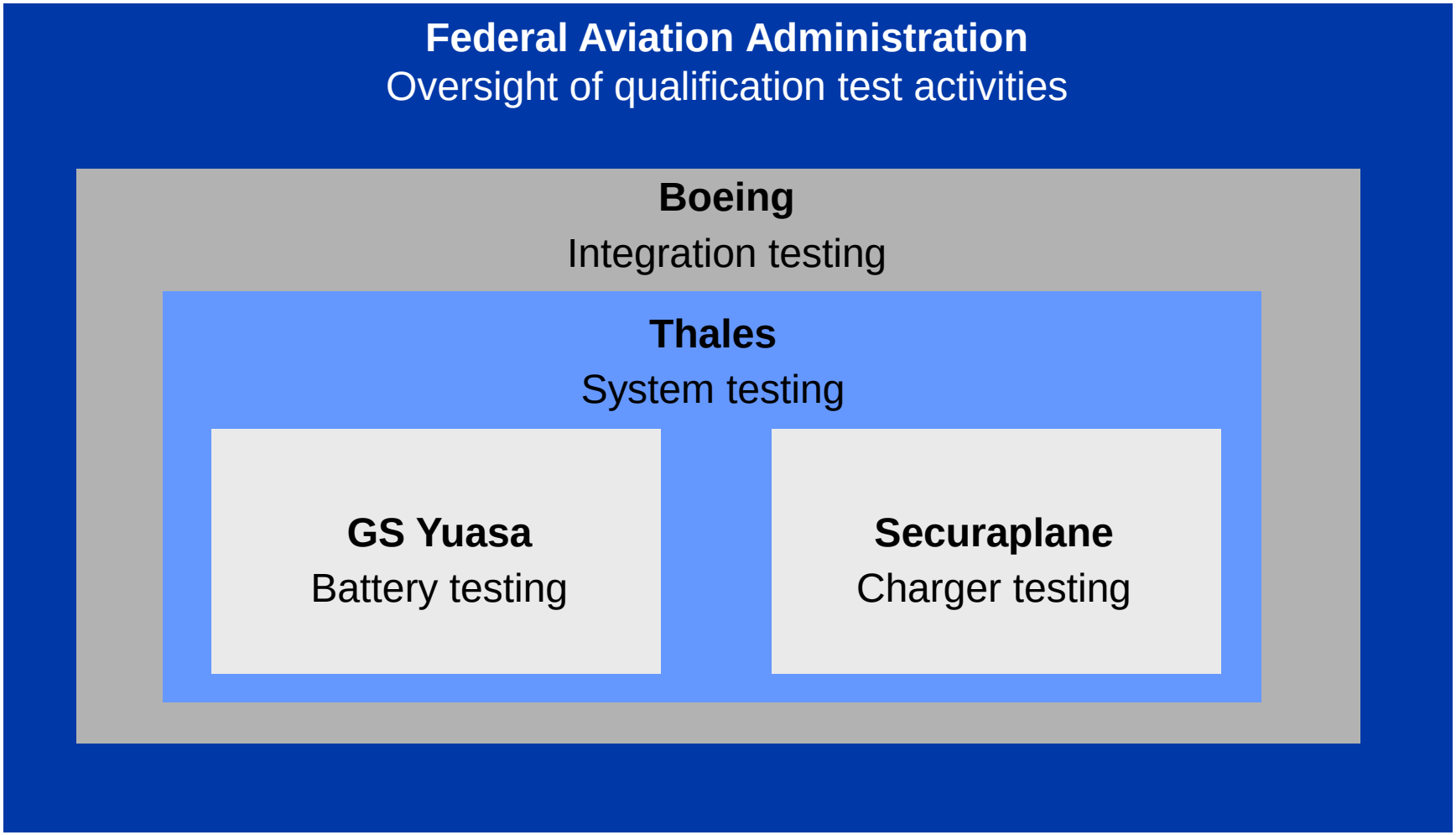
Validation for Safety

- **Qualification and system testing**
- **System safety analysis**

Validation Confirms Compliance With Safety Requirements

Qualification and System Testing

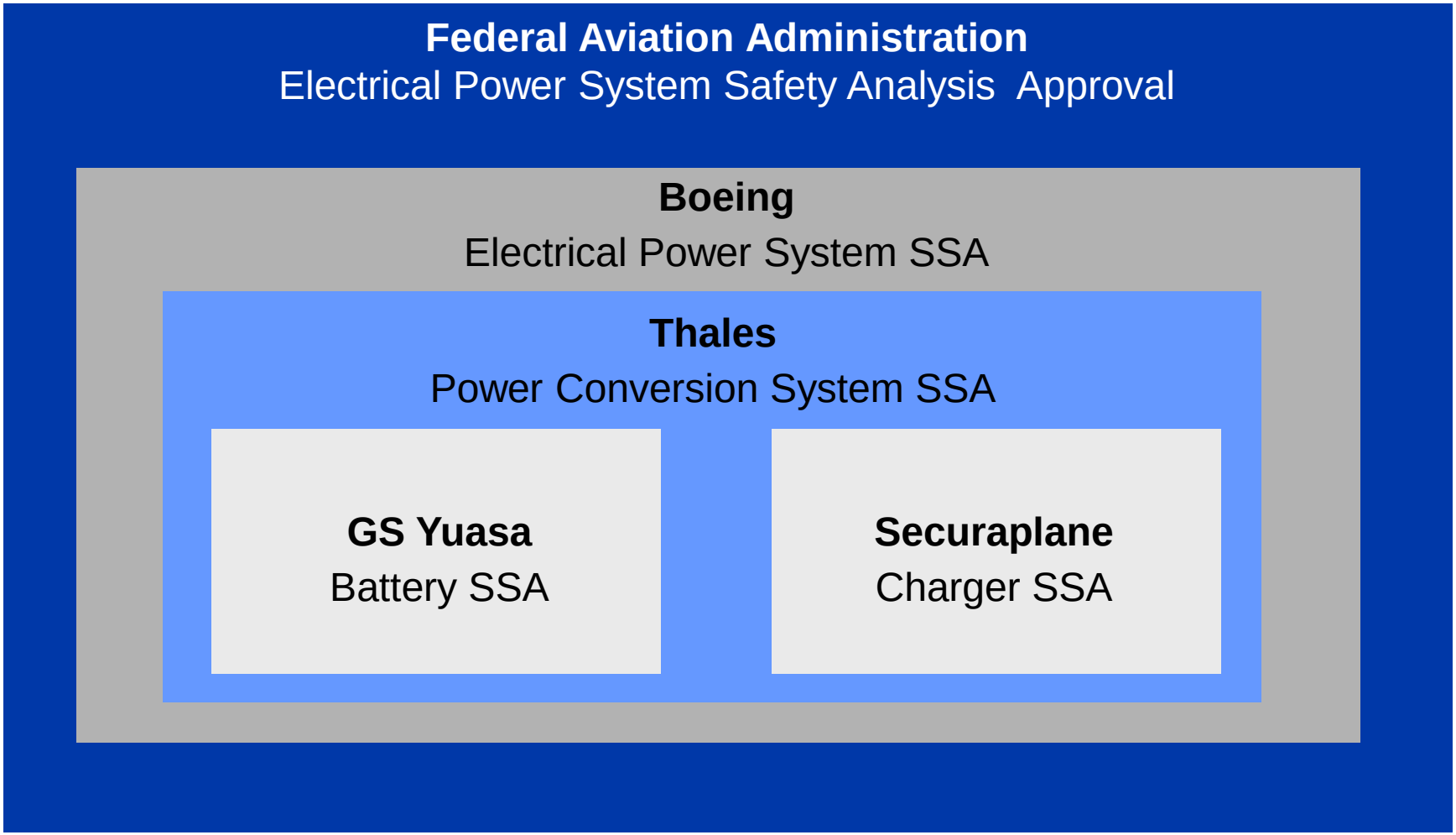


Testing Conducted in a Building-Block Fashion

Abuse Tests Conducted

Test Content	Test Article	Test Name	Eng	Cert
Abuse Tests	Cell 	Nail Penetration	✓	
		External Short Circuit	✓	
		Overheat	✓	
		Crush/Impact	✓	✓
		Step Overcharge Destructive	✓	
		Constant Current Overcharge Destructive	✓	
	Battery 	High Rate Charging	✓	
		Nail Penetration	✓	
		Flame Test	✓	
		High Temperature Storage		✓
		Low Impedance External Short Circuit	✓	✓
		High Impedance External Short Circuit		✓
		Overcharge to 36V	✓	✓
		Over discharge		✓
	Battery and Charger	External Short Circuit	✓	

System Safety Analysis (SSA)



All Parties Remained Engaged With Each Other

Summary

- **The 787 battery and charger satisfied extensive qualification tests that applied recognized industry and regulatory standards.**

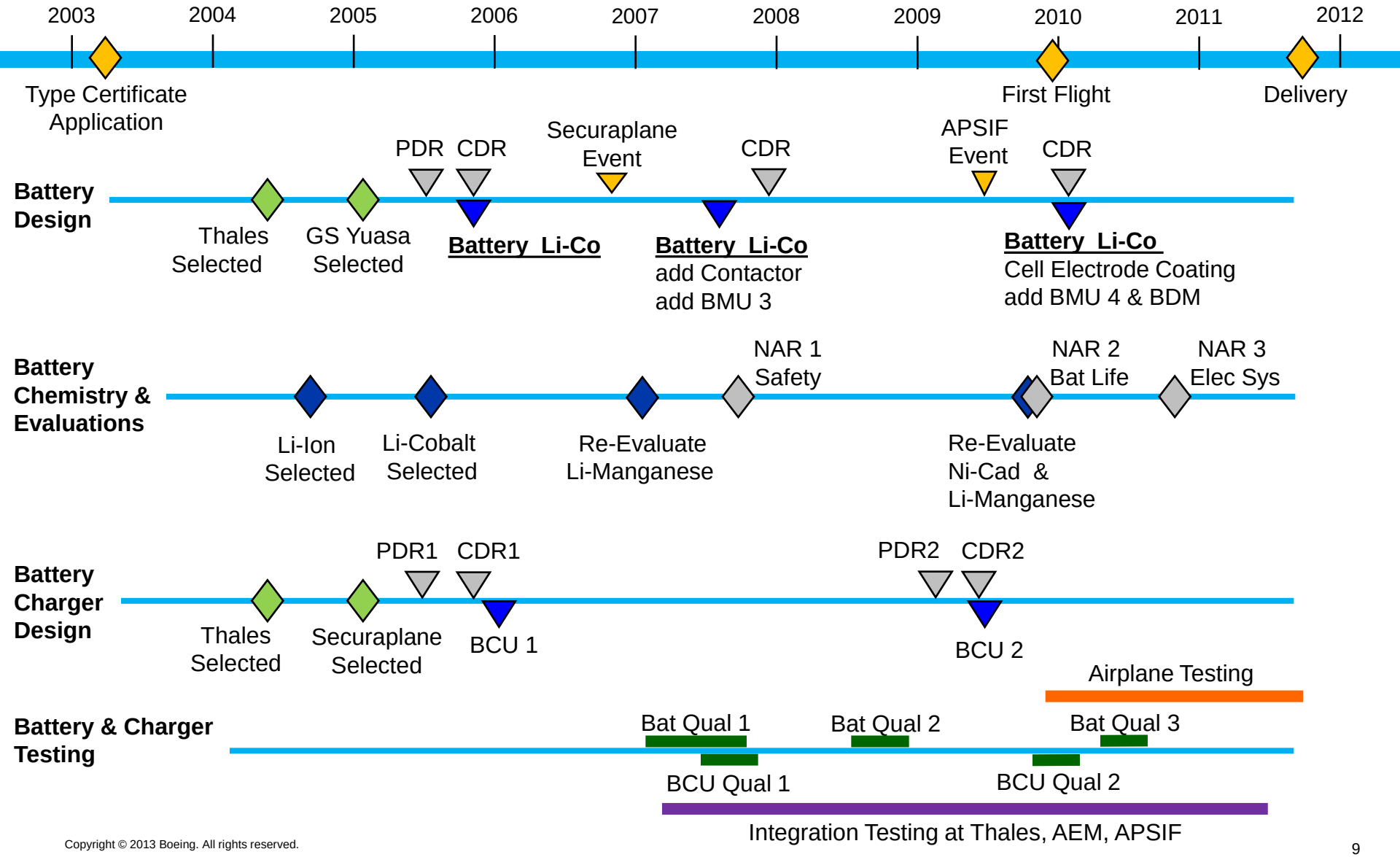
- **The established system safety analysis process validated the safety of the 787 design.**

Extensive Testing and Analysis Demonstrated Compliance


BOEING

Backup

787 Battery Design Timeline



Tests Conducted (1 of 2)

Test Content	Test Article	Test Name	Eng	Cert
Climatic	Cell	High Temperature	✓	
		Low Temperature	✓	
		Altitude	✓	
		Overpressure	✓	
		Temperature Variation	✓	
		Decompression	✓	
	Battery	High Temperature		✓
		Low Temperature		✓
		Altitude		✓
		Overpressure		✓
		Humidity	✓	✓
		Temperature Variation		✓
		Decompression		✓
		Fluid Susceptibility	✓	
Mechanical	Cell	Acceleration	✓	
	Battery	Random Vibration	✓	✓
		Fan Blade Loss / Windmilling Vibration	✓	✓
		High Power Vibration	✓	✓
		Bench Handling Shock	✓	✓
		Shipping Container Shock	✓	✓
		Acceleration		✓
		Electrolyte Leakage		✓

Tests Conducted (2 of 2)

Test Content	Test Article	Test Name	Eng	Cert
Electromagnetic Interference	Battery	AF Capacitive Coupling		✓
		AF Inductive Coupling		✓
		RF Conducted Emissions		✓
		RF Radiated Emissions		✓
		AF Electric Field Susceptibility		✓
		AF Magnetic Field Susceptibility		✓
		Conducted RF Susceptibility		✓
		Radiated RF Susceptibility		✓
		Induced Spike Susceptibility		✓
		Ground-injected Transient Susceptibility		✓
		Cable-injected Transient Susceptibility		✓
		Lightning Induced Multiple-Burst Transient Susceptibility		✓
		Electrostatic Discharge Susceptibility		✓
		BMU Function Test		✓
Other Tests	Cell	Endurance	✓	
	Battery	Endurance	✓	
		UN Transportation Tests	✓	
		Charge/Discharge Performance	✓	
	Battery and Charger	Battery / BCU Integration Tests	✓	

Abuse Tests Conducted

Test Content	Test Article	Test Name	Eng	Cert
Abuse Tests	Cell	Nail Penetration	✓	
		External Short Circuit	✓	
		Overheat	✓	
		Crush/Impact	✓	✓
		Step Overcharge Destructive	✓	
		Constant Current Overcharge Destructive	✓	
	Battery	High Rate Charging	✓	
		Nail Penetration	✓	
		Flame Test	✓	
		High Temperature Storage		✓
		Low Impedance External Short Circuit	✓	✓
		High Impedance External Short Circuit		✓
		Overcharge to 36V	✓	✓
		Over discharge		✓
	Battery and Charger	External Short Circuit	✓	

System Safety Assessment Process